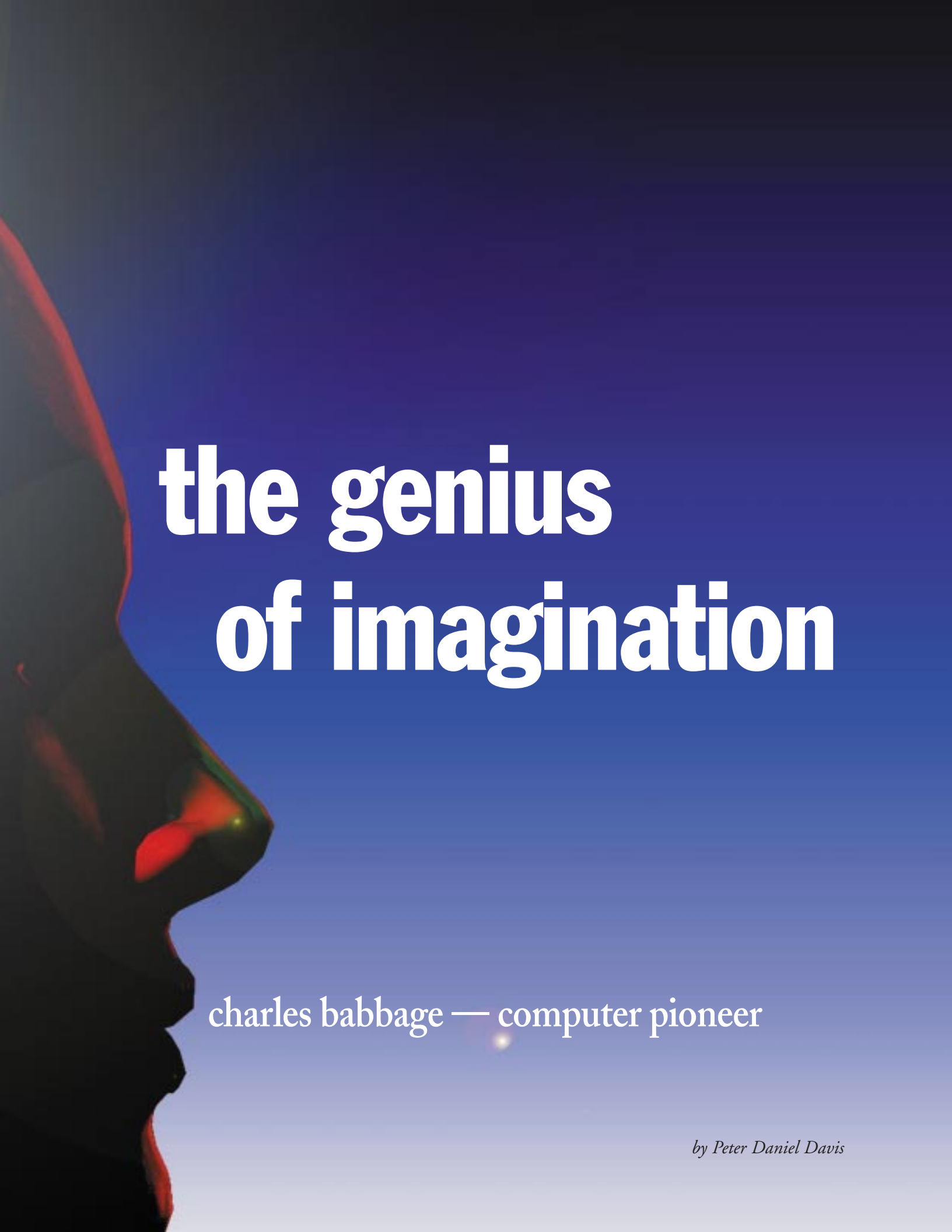


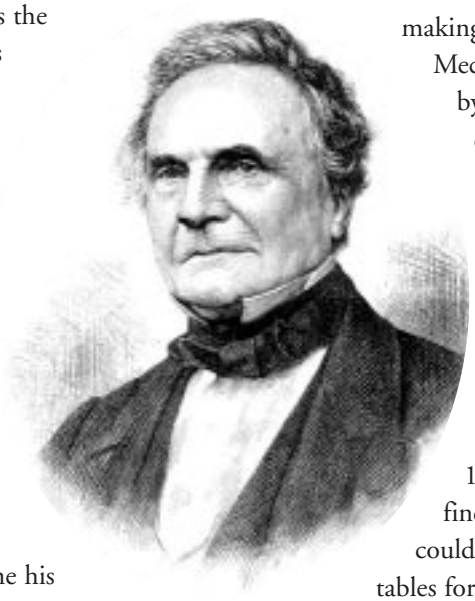
the genius of imagination

charles babbage — computer pioneer

by Peter Daniel Davis

As a youth, Charles Babbage had almost drowned using a pair of water shoes he had invented for walking on water. His inventions also included a pen with a wheel attached to it for drawing broken lines on maps and, for much of his life, he was in great demand at parties.

In the summer of 1821, John Hersehel was visiting Babbage in his London home, where the two friends were checking over written sheets of mathematical tables for the Astronomical Society. The tables were a work-in-progress, having initially been prepared by 'computers'—people who spent hours doing repetitive calculations putting together tables not only for science and astronomy, but also for industry, engineering, building, trade, banking, and insurance. It was the time of the Industrial Revolution, and volumes of these tables lined the shelves of the trades people who used them. Of no greater consequence was the astronomical one used for navigation. But these volumes were almost invariably filled with mistakes that resulted from errors in calculation, transcription, typesetting, and proofreading. The tables that the two men were reviewing had errors as well. In frustration, Babbage finally lamented, "I wish to God these calculations had been executed by steam." And so, although he always underestimated the time it would take, mechanizing mathematical computation became his life's quest.



Joseph Clement, a self-made man who was a skilled machinist and brilliant at mechanical drafting, assisted him in this quest. It was largely Clement who gave Babbage any chance of success in an age when standardization in machinery was not yet a reality, and they were faced with the problem of having to manufacture thousands of individual parts. With his assistant Joseph Whitworth, who invented the Whitworth screw thread, Babbage greatly advanced standardization in mechanical engineering.

Countess Ada Lovelace

The Countess Ada Lovelace, daughter of the poet Lord Byron, also assisted Babbage.

> ***"I wish to God these calculations had been executed by steam."***
>
> – Charles Babbage

Though it was a difficult relationship, she is credited for her work in interpreting Babbage's often hard-to-understand writing.

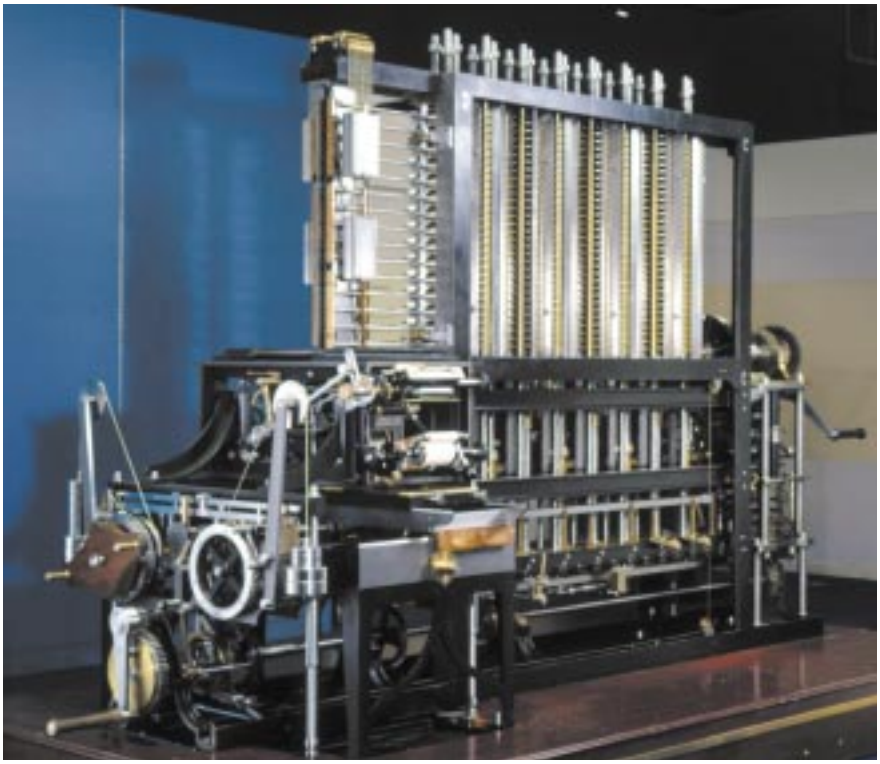
During his lifetime, Babbage designed two types of computers, the Difference Engine and the Analytical Engine, making constant variations on both of them. Mechanical calculators had already been devised by the time Babbage had begun work on his difference engine, but none worked as independently or as accurately. Slide rules had also been invented by then, but they were accurate only up to a point.

The intent of the Difference Engine was to find the common difference in a sequence of mathematical terms. For example, in the sequence "2, 4, 6, 8, 10…", the common difference is 2. By finding the common difference, the Engine could create a mathematical table. Astronomical tables for star positions at different times could then be printed out, as could tables in other disciplines.

In designing the Analytical Engine, Babbage introduced various improvements and advances. Notably, he designed separate sections for doing computations, called the Mill, and a section where numbers were stored. Appropriately enough, this was called the Store, and is analogous to what we now call memory in a computer. The Analytical Engine was actually a machine that could be programmed using punch cards. This was not unlike the use of punch cards or computer tape used in 20th century computers. Babbage freely acknowledged that the idea of using punch cards came from their use in industrial looms, in which they were used to program patterns in making woven material.

In addition to his work on computers, he published work on biology, geology, life insurance, astronomy, magnetism, religion, and economics. In 1847, he devised and built an opthalmoscope for examining the interior of the eye. His work in mathematics included probability, geometry, numbers theory, calculus, mathematical notation, and code breaking. In 1832, he also wrote the somewhat meandering but brilliant

The Analytical Engine



The #2 Difference Engine with Printer - Recently completed from Babbage's Original Design

Courtesy of the London Science Museum/Science & Society Picture Library

treatise *The Economy of Machinery and Manufactures* in which he describes the mechanical principles of machinery as applied to manufacturing. Babbage discusses needle making, the regulation of power in a steam engine, determining the direction of a shock from an earthquake, the use of diamonds for cutting glass, and a variety of printing processes. The work, which is largely an outgrowth of his need for understanding precise manufacturing processes for the Difference Engine, also considers the issues of unionizing workers, factory size, and even the very modern-day issues of technology being exported to other countries, replacing coal as an energy source, and using ocean tides as a source of power.

His work in mathematics included probability, geometry, numbers theory, calculus, mathematical notation, and code breaking.

Babbage's work on computers also helped promote thought about how a physical mechanism could be related to thought and the mind. He never completed either the Difference Engine or the Analytical Engine, although both he and, later, his son built elements of the machines. Having a need for funding from a government that was not always visionary enough to be consistently sympathetic to his task, his fractious relationship with Joseph Clement, the overwhelming complexity of manufacturing the thousands of parts, and Babbage's own tendency of revising and improving his designs before he could complete them all played a part in this.

He died a lonely man who despised street musicians and organ grinders and claimed he had never had a happy day in his life. But in 1985, Dr Allan Bromley suggested to Doron Swade of the Science Museum in South Kensington, England the idea of building one of Babbage's engines. Bromley had studied Babbage's plans and was confident it could be done. Bromley believed that Babbage's number two Difference Engine could be built as a functioning machine, choosing this particular one because none of the drawings appeared to have been lost. It was also recognized that the more complex Analytical Engine was just too great a task. But constructing the Difference Engine proved difficult enough. The builders ran into problems of design, finance, construction, and breaking parts that likely offered insight into Babbage's own struggles. Ultimately though, the functioning Difference Engine—minus the printer—was finally completed in 1991, the two hundredth anniversary of Babbage's birth. The printer was completed in 2000. The Difference Engine stands as a working remembrance of the beginnings of an idea that would change a world that came before microchips or hard drives but not before the genius of imagination.

Sources

Several books on Charles Babbage are available from book vendors on Schedule 76, Publication Media. These include *The Difference Engine*, by Doron Swade, and *Charles Babbage: Passages from the Life of a Philosopher*, edited with a new introduction by Martin Campbell-Kelly. Both books are highly readable. *The Mathematical Work of Charles Babbage* by J. M. Dubbey, though more advanced reading, gives a useful survey of the variety of Babbage's mathematical work.

The Economy of Machinery and Manufactures by Charles Babbage is available on-line at
http://socserv2.socsci.mcmaster.ca/~econ/ugem/3112babbage/babbl

Short biographies of Charles Babbage on-line:

Charles Babbage's Computer Engines
http://allsands.com/Computers/babbagecomputer_yy_gn.htm

Charles Babbage
http://ei.cs.vt.edu/~history/Babbage.html

For more information, please contact:

Lloyd Brown
(212) 264-0943
lloyd.brown@gsa.gov

Mark Coniglio
(212) 264-2670
mark.coniglio@gsa.gov

Tony Zaza
(212) 264 3548
tony.zaza@gsa.gov